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SHEER - SHale gas Exploration and Exploitation induced Risks

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www.sheerproject.eu

1. Introduction

Shale gas operations may affect the quality of air, water and landscapes; furthermore, it can induce seismic activity, with the possible impacts on the surrounding infrastructure. The SHEER project aims at setting up a probabilistic methodology to assess and mitigate the short and the long term environmental risks connected to the exploration and exploitation of shale gas. In particular we are investigating risks associated with groundwater contamination, air pollution and induced seismicity. A shale gas test site located in Poland (Wysin) has been monitored before, during and after the fracking operations with the aim of assessing environmental risks induced by fracking and injection of waste water. The severity of each of these hazards depends strongly on the unexpected enhanced permeability pattern, which may become pathway for gas and fluid migration towards underground water reservoirs or the surface. The project is devoted to monitor and understand how far this enhanced permeability pattern develops both in space and time. The considered hazards may be at least partially inter-related as they all depend on this enhanced permeability pattern. Therefore they are being approached from a multi-hazard, multi parameter perspective. We develop methodologies to track and model fracture evolution around shale gas exploitation sites and a robust, statistically based, multi-parameter methodology to assess environmental impacts and risks across the operational lifecycle of shale gas.

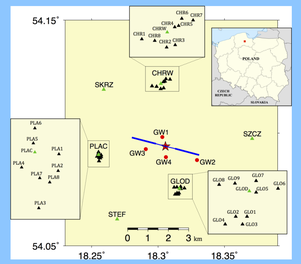
2. Data base

The developed methodologies are going to be applied and tested on a comprehensive database consisting of seismicity, changes of the quality of ground-waters and air, ground deformations, and operational data collected from the ongoing monitoring episode (Wysin) and past episodes: Lubocino (Poland), Preese Hall (UK), Oklahoma (USA), Groningen (Netherlands), Gross Schönebeck (Germany), The Geysers (USA), Cooper Basin (Australia).

Inducing technology	Name	Case type
Unconventional hydrocarbon extraction	WYSIN Shale Gas	Present case study
	LUBOCINO Shale Gas	Past case study
	PREESE HALL Shale Gas	Past case study
	*OKLAHOMA hydrocarbon extraction and wastewater injection	Past case study
Conventional hydrocarbon extraction	*OKLAHOMA hydrocarbon extraction and wastewater injection	Past case study
	GRONINGEN FIELD conventional hydrocarbon production	Past case study
Geothermal energy production	GROSS SCHÖNEBECK geothermal energy production experiment	Past case study
	THE GEYSERS geothermal energy production	Past case study
	COOPER BASIN geothermal energy injection experiment	Past case study
Wastewater injection	*OKLAHOMA hydrocarbon extraction and wastewater injection	Past case study

3. Test site (Wysin, Poland)

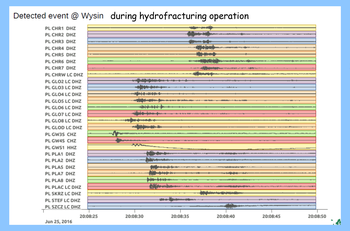
We develop a monitoring execution plan agreed with the PGNiG operator and we arrange the Polish test site (Wysin) for the collection of a complete suite of operational, geomechanical, seismic, groundwater and atmospheric chemistry data from planned hydraulic fracturing activity performed during June 2016.



- Seismic monitoring at Wysin with all surface (3 arrays: PLAC, GLOD, CHRW, equipped with short period and broadband sensors) and borehole stations (GW1, GW2, GW3) started enough before hydrofracturing operations to capture background seismicity level, collecting seismic data during and after the technological operations;
- A groundwater regular monitoring and sampling regime has been established with data collection ongoing (GW1,GW2, GW3, GW4);
- Air quality monitoring is ongoing and all trace gases and particulate matter foreseen by the monitoring plan are measured continuously, via the Stary Wiec station, 1200 m far away from the Wysin site

Red star shows the hydrofracturing site.

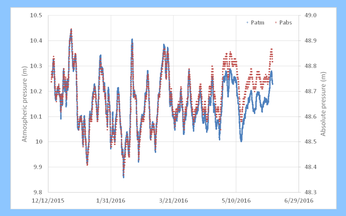
4. Geophysical monitoring



The detection and characterization of induced seismicity, its role to image fracture processes and fluid transfers and the assessment of seismic hazard is key feature for the SHEER project.

- Development of tools to generate realistic synthetic catalogues and waveforms, preparation of an extended synthetic seismic catalogue for the Wysin site;
- Full development of a method to estimate the detection performance, minimum detectable magnitude and magnitude of completeness for hydraulic fracturing operations, using pre-operational noise records and synthetic data.

Baseline hydrogeological conditions in near surface aquifers have been analysed. The development of a hydrogeological groundwater flow model and analysis of groundwater chemistry are being undertaken to establish any changes to the baseline conditions as a result of drilling fracture stimulation.



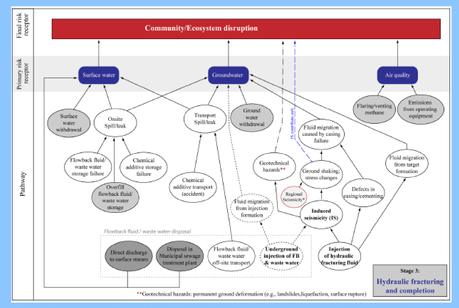
Variation in atmospheric pressure (blue) and absolute water pressure (orange) recorded by the transducer in borehole GW1 during the baseline period.

Month 2016	IV	V	VI	VII	VIII	IX	X
NO(ppb)	0.9	0.7	0.8	0.5	0.6	1.3	0.9
NO_2(ppb)	4.1	3.2	3.3	2.7	3.3	4.6	4.8
NO_x(ppb)	5.0	4.0	4.1	3.1	3.6	5.9	6.2
CO (ppb)	206.1	166.8	153.7	136.0	139.5	153.1	226.0
CO_2(ppm)	416.9	408.1	411.5	410.5	417.7	429.4	413.2
O_3 (ppb)	33.2	42.7	33.7	27.6	24.6	23.8	16.4
PM10(µg)	15.4	16.4	15.2	13.3	12.7	15.5	13.8
CH_4(ppm)	1.90	1.93	1.93	1.91	1.90	1.92	1.91
NMHC(ppmc)	0.04	0.02	0.02	0.02	0.02	0.03	0.05
^{222}Rn (Bq/m^3)	6.1	6.8	8.6	7.3	6.2	9.9	5.2

Measurements of selected air pollutants have been carried out to determine background levels of pollutants;
Analysis of 7 months of available air pollution data collected after the "background" period. No significant episodes of basic air pollutants that could be attributed to the shale gas exploitation activities have been detected.

Monthly means of air pollutants concentration (April - October 2016)

5. Multi-risk and dissemination activity



Risk pathways identified for the fracturing and well completion phases.

The main objective of a multi-hazard/multi-risk assessment applied to shale gas operations, as set within the SHEER project framework, is to identify and to assess the rate (or the likelihood) of occurrence of incidents, and their potential impacts on surrounding environment, taking into account different hazards and their possible interactions through identification of plausible scenarios of events or chains of events related with shale gas development that may have an impact on the environment and/or the society

- Assessing the risk pathway scenarios, adopting a bow-tie" structure;
- Identification of 56 pathway scenarios. Classified by project phase, those scenarios are divided as follows: 11 scenarios were identified for the site development and drilling preparation phase; 7 scenarios for the drilling activities; 21 scenarios for the fracturing and well completion phase; 11 scenarios for the production and operation phase; and 6 scenarios for the well abandonment and post-abandonment phase;
- Analysis of socio-economic impacts related to shale gas operations.

The main objective is to develop best practice for risk management and recommendations for monitoring the environmental impacts due to shale gas operations.
A key aspect of the SHEER project is to inform the community about the possible hazards and how these can be assessed and mitigated.

- Creation and implementation of a dissemination plan
- Creation of the SHEER website
- A review of the applicability of ISO 31000:2009 to the project outcomes
- Four issues of the SHEER newsletter
- Continuous update of the SHEER social media pages
- SHEER interaction with other H2020 LCE16 winning projects

6. Relevant publication of the project

Bommer, J.J., B. Dost, B. Edwards, P.J. Stafford, J. van Elk, D. Doornhof and M. Ntinalexis, 2016, Developing an Application Specific Ground Motion Model for Induced Seismicity, *Bull. Seism. Soc. Am.*, 106: 158–173, doi: 10.1785/0120150184
Dost, B., and J. Spetzler, 2015. Probabilistic Seismic Hazard Analysis for Induced Earthquakes in Groningen, *KNMI report*
Orlecka-Sikora, B. & Lasocki, S. Interval Estimation of Seismic Hazard Parameters, *Pure Appl. Geophys.* (2016) pp 1-13. doi:10.1007/s00024-016-1419-4. Available at http://link.springer.com/article/10.1007/s00024-016-1419-4
C.M. Profiriou, P. Gasparini, V, Ivan (2015). Uncertainty in the Shale Gas Debate: Views from the Science– Policymaking Interface. Transylvanian Review of Administrative Sciences, No. 46 E/2015, pp. 144-161.
Younger P., How can we be sure fracking will not pollute aquifers? Lessons from a major longwall coal mining analogue (Selby, Yorkshire, UK Earth and Environmental Science Transactions of The Royal Society of Edinburgh, June 2016, Volume 2 pp. 89-113.
Zollo, A., Orefice, A., and Convertito, V., 2014. Source parameter scaling and radiation efficiency of microearthquakes along the Irpinia fault zone in southern Apennines, Italy, *J. Geophys. Res.*, doi: 10.1002/2013JB010116

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